PRODUCTION OF BIOFERTILIZER FROM VERMICOMPOSTING PROCESS OF MUNICIPAL SLUDGE

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ABSTARCT

The potential of the epigeic tiger worms (*Eisenia fetida*) in this study is aimed at safe reuse and recycling of municipal sewage sludge (MSS) in vermicomposting process and the major nutrient status, its simple vermicompost were assessed across different periods in relation to its respective initiative substrates. The present study aims to find out the possibility of utilization of sewage sludge for vermiculture. 1000 g of tiger worms were cultured in plastic container (0.55 wide x 0.30 high x 0.25 long) metre containing 25000 g sewage sludge. The optimum daily feeding rate of sludge is equal to the weight of worm biomass in the bin. This bin was used to calculate the sludge volume reduction by vermicomposting process and it was determined that there is a nearly 90% of volume reduction. Their physical parameters – temperature and moisture is maintained also the pH is decreased (alkali to acidic) during the vermicomposting process, were recorded. The nutrients –total nitrogen (TN), Total phosphorus(TP), and Total potassium(TK) in the vermicast as the process progressed from 0 to 1, 7, 14 and 21 days were also obtained. It was found that the vermicast are rich in nutrients of Nitrogen, Phosphorus and Potassium. The present study also inferred that the application of sewage sludge can be reused and retreated as a good quality biofertilizer in agricultural fields after vermicomposting would not have any adverse effect to the environmental. Results indicate that vermicomposting might be useful for managing the energy and nutrient rich sewage sludge on a low-input basis. Products of this process can be used for sustainable land restoration practices. The feasibility of tiger worms may also reduces the possibility of soil contamination. The advantages of this concept are high performance, easy collection of compost and long run without cleaning. Worms were also produced as a very useful by-product.

ABSTRAK

Potensi epigeic cacing harimau *(Eisenia fetida)* dalam kajian ini adalah bermatlamat kepada guna semula yang selamat dan kitar semula kumbahan enapcemar perbandaran (MSS) dalam proses pembajaan vermi dan status nutrien utama, merupakan baja vermi mudah telah ditaksir merentasi tempoh-tempoh yang berbeza berkaitan dengan inisiatif substart masing-masing. Kajian bertujuan dalam mengetahui kemungkinan penggunaan kumbahan enapcemar untuk budaya vermi boleh di laksana. 1000 g cacing harimau hidup dalam bekas plastik berukuran (0.55 lebar x 0.30 tinggi x 0.25 panjang) meter yang mengandungi 25000 g kumbahan enapcemar. Kadar pemakanan cacing terhadap kumbahan enapcemar pada harian optimum sama dengan berat cacing dalam tong. Tong ini digunakan bagi mengira pengurangan isipadu enapcemar oleh proses pembajaan organik dan ia telah menentukan bahawa hampir 90% pengurangan isipadu. Parameter-parameter fizikal iaitu suhu dan lembapan di kekalkan dan nilai pH menurun (alkali kepada asid) semasa proses pembajaan vermi dan telah direkodkan. Nutrien itu ialah nilai jumlah nitrogen (TN), jumlah fosforus (TP), dan jumlah kalium (TK) dalam baja vermi berjalan dalam jangka masa dari 0 hingga 1, 7, 14 dan 21 hari juga di perolehi. Di dapati bahawa baja vermi kaya dalam nutrien Nitrogen, Phosphorus dan Potassium. Kajian menunjukkan dan kesimpulan di buat bahawa penggunaan kumbahan enapcemar itu boleh digunakan semula dan berundur kepada satu baja organic berkualiti dalam sektor pertanian selepas pembajaan vermi yang tidak mempunyai sebarang kesan buruk untuk alam sekitar. Keputusan menunjukkan yang pembajaan vermi boleh di jadikan untuk menguruskan penggunaan tenaga dan kaya dengan zat makanan enapcemar kumbahan pada satu input asas yang rendah. Produk yang di proses ini boleh digunakan untuk amalan pemulihan tanah mampan. Kemungkinan cacing-cacing harimau juga dapat mengurangkan pemalaan tanah. Kelebihan bagi konsep ini adalah prestasi yang tinggi, koleksi pengumpulan kompos yang mudah dan jangka masa yang panjang tanpa pembersihan. Cacing-cacing juga dapat menghasilkan satu hasil sampingan yang sangat berguna.

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LIST OF SYMBOLS

TN	-	Total nitrogen
TP	-	Total phosphorus
TK	-	Total potassium
NPK	-	Nitrogen phosphorus potassium
MSS	-	Municipal Sewage Sludge
pH	-	Alkalinity and acidity
et al	-	With friends
mg/L	-	Milligram per liter
m	-	meter
kg	-	kilogram
g	-	gram
CO_2	-	Carbon Dioxide
NH_4	-	ammonia
NH_3	-	ammoniacal
NO_3	-	Nitrate
Ca	-	Calcium
Mg	-	Magnesium
Na	-	Sodium
%	-	Percentage

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Vermicomposting is the conversion of biodegradable garbage into a high quality chemical free bio-fertilizer with the aid of Earthworms. Whereas, the composting is the other way round where the organic part of the refuse is consumed by a series of successive bacteria according to the heat of the system.Earthworms have from time immemorial played a key role in soil biology by serving as versatile natural bioreactors to harness and destroy soil pathogens, thus converting organic wastes into valuable bio-fertilizers, enzymes, growth hormones and proteinaceous worm biomass. The worms do it by feeding voraciously on all biodegradable refuse such as leaves, paper (non-aromatic), kitchen waste, vegetable refuse. It then burrows deep into the soil, positioning its castings towards the surface of the soil thereby enriching the soil with a pre-digested, easy to assimilate bio-fertilizer that is now rich with NPK. So when looking for a fertilizer for a farm or garden it would do well if people would consider the revolutionary vermicompost as an option. Certain types of earthworms ingest, digest, and excrete vermicompost with excellent nutrient content (Bhiday, 1995). Ingestion ensures the sorting out of only organic matter while the digestion accelerates the maturing process. Excretion ensures the grading of the vermicompost as opposed to any inorganic matter, which may be existing in the waste and not concerned with the biological activity in the earthworm gut. During the composting process, microorganisms decompose organic compounds, which consist of carbohydrates, sugar, proteins, fats, cellulose and lignin. Carbohydrates are more easily decomposed whereas lignin is more resistance to decomposition. Many factors affect the composting process. Aerobic microorganisms need oxygen, water and nutrients for their metabolism and cell synthesis. As a result of microbial activity heat is liberated and, if contained within the composting mass, the temperature rises. Temperature increases through the mesophilic phase into a thermophilic phase and then back in to the mesophilic phase. During the course of these transitions, the microbial population changes, thereby affecting the rate of organic matter decomposition.

2.2 Definition

2.2.1 Vermicomposting

The method of employing earthworms in reducing the organic matter present in the waste is called as the vermicomposting. Vermicomposting, also known as worm composting, is simply the way redworms transform decaying organic matter into worm castings (Zorba, 1998). Vermicomposting is the process involved in the degradation of organic waste into useful components by using earthworms. It is all-together a natural system in which the earthworms play their major roles in degrading the organic portion of the waste. The use of earthworm in sludge management is called as vermicomposting or vermistablization. (Edward et al., 1988).

2.2.2 Composting

Composting is the biological decomposition of organic matter under controlled aerobic condition (Epstein, 1977). Composting in a way is one such method by which we can practically and economically use those waste streams dominated by organic refuse. As stated by Roger (1993) that there is no universally accepted definition of composting.According to him, it is the biological decomposition and stabilisation of organic substrates, under conditions that allow development of thermophilic temperatures as a result of biologically produced heat, to produce a final product that is stable, free of pathogens and plant seeds, and can be beneficially applied to land. Or simply it can be defines as the biological reduction of the organic waste to humus (Jerry, 1979). In brief we can consider composting as a way of stabilising the waste.

2.3 Types of vermicomposting systems

2.3.1 Windrows

This system takes into account the availability of large land and other appropriate technology for operating the whole system. These systems are extensively being used for used both in the open and under cover.

2.3.2 Wedge system

This is a modified type of windrow system where one can easily harvest the vermicompost without disturbing the earthworms. In this system organic materials are applied in layers against a finished windrow at a 450 angle.

2.3.3 Bed and bin system

Here in this systems bins are used to breed and harvest the vermicompost and also in some case beds are made on the ground for the same purpose. This method is labor intensive but is much easier to handle and is widely.

2.3.4 Reactor system

Reactor systems have raised beds with mesh bottoms. Finished vermicompost is harvested by scraping a thin layer from just above the grate, and then it falls into a chamber below. These systems can be relatively simple and manually operated or fully automated with temperature and moisture controls. Factors that may be considered for selecting the appropriate vermicomposting technology for a project include: Amount of feedstock to be processed; Funding available;Site and space restrictions; Climate and weather; State and local regulatory restrictions; Facilities and equipment on hand; and Availability of low-cost labors etc.

2.4 Breeding of earthworms

Worms will be breeded by setting up a vermibed in a suitable container or a site under a shade, in an area on upland or an elevated level to prevent water stagnation in the pit.

2.4.1 Bedding preparation

For the preparation of the bedding we can have various choice regarding the availability of the bedding materials. Here in the below figure show the basic requirements for a Vermibed. In the setting up of an ideal vermibed one should have the following layers, basal layer comprising of broken bricks or pebbles to a small extent followed by coarse sand to a thickness of 6 – 7.5 cm, this layer is to ensure proper drainage. This is topped by a layer of loamy soil up to a height of not less than 15 cm after it is moistened. Now we can inoculate worms here in this layer. Over this small lump of cattle dung are scattered over the soil and this is covered by layer of hay up to a height of 10 cm. Broad leaves finally cover the unit and a net can be used to prevent the intrusion of any unwanted worms or other predators. (Ismail, 1997).

2.4.2 An ideal environment for earthworms

The following are the environmental conditions, which are vital and may affect the breeding, cocoon production and hatching of young earthworms. They are lots of literature describing the various limiting parameters towards a successful breeding.

2.4.2.1 Temperature

In Vermicomposting, temperatures are kept generally kept below 350C(Riggle et al., 1994). Most worm species used in vermicomposting require moderate temperatures from (10-35)0C. While tolerances and preferences vary from species to species, temperature requirements are generally pretty similar. The majority of vermicomposting worms can tolerate temperatures ranging from 50 °F to 85°F but decrease activity as temperatures move toward the extremes. Most species prefer temperatures within roughly ten degrees of 70 °F.

2.4.2.2 Moisture

Earthworm requires plenty of moisture for growth and survival, they need generally moisture at the range from (60 –75) %. The soil should not be too wet else it may create an anaerobic condition which may drive the earthworms from the bed (Ronald et al., 1977). It is very important to moisten the dry bedding material before putting them in the bin, so that the over all moisture level is well balanced.

2.4.2.3 pH

Although studies have suggested that worms perform best in neutral pH (Ronald et al., 1977). It has been recorded by Edward et al., (1976) that different species of earthworms have their own pH sensitivity and generally most of them can survive at the pH range between (4.5 – 9).

2.4.2.4 Feed

The first step in starting a vermicomposting unit is to arrange for regular input of feed materials for the earthworms. These can be in the form of a nitrogen rich material like goat manure cattle dung and pig manure. When the material with high carbon content is used with C/N ratio exceeding 40: 1, it is advisable to add nitrogen supplements to ensure effective decomposition. All organic matter should be added only as a limited layer as an excess of the former may generate heat (Ismail, 1997). From the waste eaten up by the worms 5 – 10 % are being assimilated in their body and the rest are being excreted in the form of a nutrient rich cast.

2.4.2.5 Stimulants

They are no known stimulants which will force the earthworms to breed but fairly fresh manure or other nitrogen rich green organic matter seems to be the best stimulant to rapid breeding (Ronald et al., 1977).

2.5 Biology of earthworm

The earthworm is a tube shaped, segmented, invertebrate. Lacking bones or cartilage, its body holds its shape because it's full of a thick mucous-like liquid called coelomic fluid. If one were to view a cross section of the worm body it would resemble a target, with the center representing the internal organs and the outer circle representing the skin or dermal layer. The cavity between the internal organs and dermal layer is filled with the coelomic fluid. The pressure of this fluid against the dermal layer gives the worm its shape (Slocum, 2001).

2.5.1 Classification of earthworm

According to their feeding habits, earthworms are classified into detritivores and goephages . Detritivores feed near the soil surface. They feed mainly on the plant litter or dead roots and other plant debris in the soil. These worms comprise the epigeic and the anecic forms. Geophagous worms, feeding deeper beneath the surface ingest large quantities of organically rich soil. These are generally called as humus feeders and comprise of endogeic earthworms.Epigeic are surface dwellers serving as efficient agents in fragmentation of organic matters on the soil surface. Whereas the anecics feed on the organic matter mixed with soil. Endogeic earthworms live deep within the soil and derive their nutrition from the organically rich soil they ingest. The distribution of earthworm in the soil is influenced by several factors of which are soil texture and aeration, temperature, moisture, pH, inorganic salts and the organic matter (Govindan, 1998)

2.5.2 Types of earthworms

In general we have six common types of earthworms (Ronald et al., 1977).

1. The native night crawler, or Lumbricus terrestris.
2. The common field worm, or Helodrilus caliginosus
3. The green worm, or Helodrilus chloroticus.
4. The manure worm, or Eisenia foetida.
5. The slim earthworm, or Diplocardia verrucusa
6. The red worm, or Lumbricus rubellus.

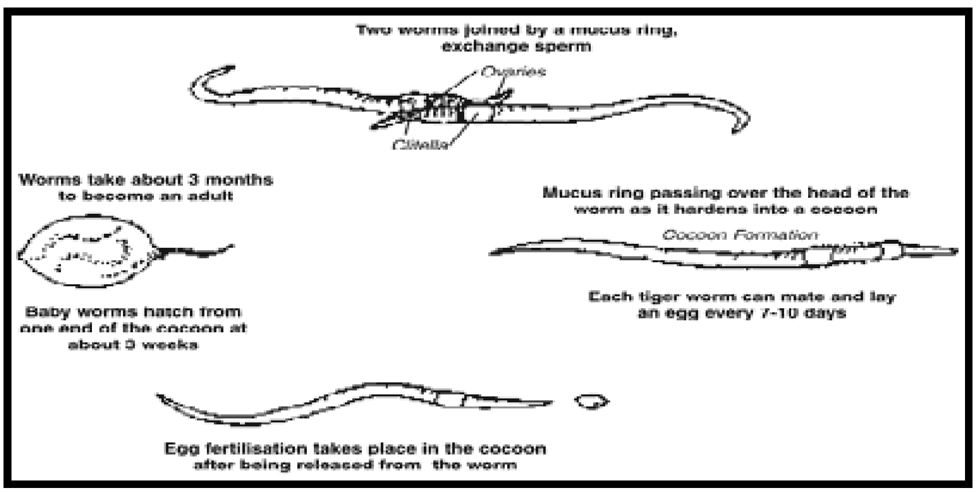
2.5.3 Reproduction

Earthworms are hermaphrodite, which is each individual has its own male and female reproductive organs. In sexually matured earthworms the body wall of the forward segment is thickened by gland cells, forming a conspicuous girdle known as clitellum (Ronald et al., 1977). During reproduction they exchange sperm at a point just above the clitellum, the swollen band encircling the worms body. After sperm of worms move apart and secrete a thick mucous around the clitellum, which forms a jelly-like band. Once the band slips off the worm’s body, the ends close, forming a cocoon with sperm and eggs inside where fertilization takes place.

2.5.4 Life cycle

In their natural habitat, earthworms follow a well-defined yearly cycle. This cycle is considered to starting at the autumn season (Ronald et al., 1977). Life cycle of an earthworm is divided into four major phases.

Figure 2. 1 Schematic diagram representing the life cycle of an earthworm (http://www.tdc.govt.nz/pics/1927-worm-life-cycle.gif)



2.5.4.1 Cocoon phase

Many cocoons were produced when the temperature rises up and the greatest number occurred between May and July. Thereafter, the numbers of cocoons produced decreased quite rapidly with falling temperature. Lofty et al., (1976) reported that fewest cocoons were produced during winter and there was a temperature threshold of about 3°C, below which no cocoons were produced.

2.5.4.2 Juvenile phase

On hatching the worms measure to an average up to 0.8 – 1.5 mm in length and weigh around 7 mg. Their length gradually increases to about 4 cm and may latter weigh up to 150 mg .

2.5.4.3 Non- clitellates

Young earthworms whose clitellum are yet to develop are grouped into this nonclitellates here the young worms are very active at this stage and will weigh up to from 150 mg to 450 mg .

2.5.4.4 Clitellates

Clitellates are the mature and adult worms. Clitellates have the potentials for reproduction, the worms at this stage will appear bit darker in their colour due to the pigmentation of the epithelial cells . Here in this stage of life the body wall of the forward cell is thickened by gland cells, forming a conspicuous girdle known as Clitellum (Ronald et al., 1977).